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AICGSPOLICY**REPORT**

PART THREE: INNOVATION IN THE UNITED STATES AND GERMANY: THE FUTURE

Christopher T. Hill
Jan U. Becker

AMERICAN INSTITUTE FOR CONTEMPORARY GERMAN STUDIES THE JOHNS HOPKINS UNIVERSITY

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AMERICAN INSTITUTE FOR CONTEMPORARY GERMAN STUDIES

THE JOHNS HOPKINS UNIVERSITY

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FOREWORD

As mature, post-industrial economies, the United States and Germany confront a promising, if uncertain, future in the realm of innovation. How they approach that future—what they choose to do and not to do; what they find themselves able and unable to do—could prove to be decisive in determining their ability to maintain high living standards at home and a modicum of socio-economic stability both within and outside the Trans-Atlantic partnership. In this final report of AICGS' Innovation Series, Professor Christopher Hill of George Mason University provides an assessment of the implications of what he calls a "post-scientific society" in which innovation and productivity growth is based on the mastery of creative powers and the basic sciences of individuals and societies. Dr. Jan Becker of the Christian-Albrechts-University in Kiel examines the biotechnology and e-entertainment industries in Germany as examples of broader trends in German innovation policy and shows how policymakers can react in order to foster greater innovation in Germany.

These studies represent the importance of transatlantic learning in the crucial dimension of innovation. There is no one model for successful innovation policy, but lessons do exist which can be learned and applied in a variety of contexts. These volumes are the beginning of a longer series of studies in comparative innovation in Germany and the United States and we hope you find them to be a rich source in exploring this vital field.

This project is undertaken as part of the AICGS Economics Program, which seeks to generate insights into the institutional, political, cultural, and historical factors that shape responses to deepening economic integration and the challenges of globalization. The three Policy Reports in this series explore the crucial role played by market-driven technologies in stimulating economic growth in the Trans-Atlantic arena.

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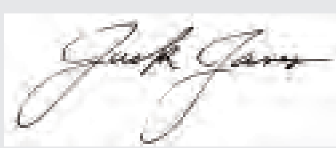

Jackson Janes
Executive Director
AICGS

ABOUT THE AUTHORS

CHRISTOPHER T. HILL has been on the faculty of the School of Public Policy at George Mason University since 1994, where his work is on the history, design, evaluation, and politics of federal policies to stimulate commercial technological innovation. After formal education and experience in engineering, Dr. Hill has spent more than three decades in practice, research, teaching, and consulting in science and technology policy. From 1997 to 2005, he served as Vice Provost for Research at George Mason and was the founding President of George Mason Intellectual Properties, Inc. He was a Public Policy Scholar at the Woodrow Wilson International Center for Scholars in 2005-2006. He has been at RAND, the National Academies, the Congressional Research Service, MIT, the Office of Technology Assessment, Washington University in St. Louis, and the Uniroyal Corporation. As a Principal in Technology Policy International, he has consulted extensively with Japanese government agencies regarding industrial competitiveness and reform of R&D funding and higher education systems. Dr. Hill earned a Ph.D. in Chemical Engineering at the University of Wisconsin, Madison, in 1969 and a B.S. in the same field at the Illinois Institute of Technology in 1964.

JAN U. BECKER, PHD is assistant professor of Marketing at the Institute for Innovation Research at the Christian-Albrechts-University at Kiel. His research focuses on marketing of innovation and media products and management of customer relationships. Before returning to academia, Jan has held several positions in the telecommunications industry and strategy consulting.

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THE AMERICAN INNOVATION SYSTEM IN THE POST-SCIENTIFIC SOCIETY

CHRISTOPHER T. HILL

The United States is blessed with an extraordinarily successful system for the generation and application of innovation, as evidenced by its world leadership over the past half century or more in developing and putting to use new technologies for commercial, civilian, and national security purposes.[1]

Firms in the United States have mastered wave after wave of new technologies, including aerospace; electronics, telecommunications, computing, and networking; chemicals, pharmaceuticals, and biotechnology; and advanced materials and nanotechnology. These fields of endeavor have been built on strong foundations of new knowledge and understanding of the physical, mathematical, and biological sciences and of engineering. They have benefited from the establishment over time of a highly supportive "National Innovation System." The combination of mastery of the scientific and engineering foundations and the smooth functioning of its National Innovation System has enabled the United States to move effectively in little more than a century from an agricultural, to an industrial, to a post-industrial society.

As the twenty-first century has unfolded, however, radical new challenges and opportunities suggest the emergence of yet another era in the development of advanced societies. I call this new era the "Post-Scientific Society."[2] A Post-Scientific Society has several key characteristics, the most important of which is that innovation leading to wealth generation and productivity growth is increasingly based, not on mastery of the natural sciences and engineering, but on mastery of the creative powers of, and the basic sciences of, human individuals and cultures.[3]

To be sure, just as the Post-Industrial Society continued to require the products of both agriculture and manufacturing for its effective functioning, so, too, does the Post-Scientific Society continue to require the products of scientific and engineering research and development. Nevertheless, the leading edge of innovation, whether for business and industry, consumer, or public purposes, is moving from the workshop, the laboratory, and the office to the studio, the think tank, the atelier, and cyberspace.

There are growing indications that new innovation-based wealth in the United States is arising from something other than organized research and development. Companies based on radical innovations, exemplified by network firms such as Google, YouTube, eBay, and Yahoo, create billions in new wealth with only modest contributions from R&D as it has been commonly understood. Huge and successful firms like Walmart, FedEx, Dell, Amazon.com, and Cisco have grown to be among the largest in the world, not by mastering the intricacies of physics, chemistry, or molecular biology, but by structuring human work and organizational practices in radical new ways. The new ideas and concepts that support these Post-Scientific Society companies are every bit as subtle and important as the fundamental science and engineering that supported the growth of firms like General Motors, DuPont, and General Electric in the past. But, they are fundamentally different.

The emergence of the Post-Scientific Society poses a fresh round of challenges to the American National Innovation System, or NIS. The existing NIS, and it really is a "system" in the strongest sense of that word, has enormous momentum. Some of its elements—such as the great public and private universities, large industrial research laboratories, and federal R&D agencies—dominate the landscape of discussion of innovation policy. This is well-illustrated by a recent report of the National Academies, commonly known as the "Gathering Storm Report."[4] This report, which was intended to summarize the major recommendations of all recent reports advocating actions to enhance U.S. competitiveness, calls for reinforcement of education in math, science, and engineering, as well as for increased federal investments in R&D, especially in the physical sciences and engineering. This report, which has received very broad acceptance, is one of the principal sources underlying President Bush's "American Competitiveness Initiative," or ACI. The ACI highlights Gathering Storm's recommendations for more public spending to reinforce certain elements of the existing NIS.

National Innovation Systems

The concept of the National Innovation System (NIS) has been developed and widely popularized by Richard Nelson and others.[5] According to Nelson and Rosenberg, an NIS is the set of institutions whose interactions determine the innovative performance of national firms.[6] While the boundaries of an NIS are not sharp, it has generally been understood to include *inter alia* the institutions and organizations that finance and perform R&D, that finance investments in technology-based start-ups and new ventures, that attend to the management of the undesirable consequences of new technology including the establishment and enforcement of standards; a regime of intellectual property rights creation and enforcement; supportive tax policies and investment policies; and the institutions for the education and training of the technical work force at all levels.

The National Innovation Systems framework has proven very popular for comparing the structures and performance of nations against each other. While views on the essential elements of an NIS differ among authors, this same framework has often been employed to assess whether emerging nations have an NIS that would enable them to make the transition from a developing to an industrial economy that could compete in world markets with advanced nations.

From an NIS perspective, the task of innovation policy is to ensure that the nation has a coherent, well-managed, and well-funded set of private and public institutions that function well as a national innovation system. The NIS idea does not provide a cookbook that nations can use to create such a system. Each nation seeks its own best recipe for an NIS that fits its blend of governance principles, culture, and place in the world. Within nations, there is continual experimentation with the design and elements of an NIS—policies, programs, practices, priorities, funding, and other aspects change as national goals and challenges change, as experience is gathered, and as new ideas are tested and then incorporated in national systems based on benchmarking of best practices around the world.

The Scientific Society

Denoting the emerging new era the "Post-Scientific Society" suggests, of course, that America is moving ahead from a prior "Scientific Society." This requires elaboration.[7]

America's emergence as a world industrial power in the late nineteenth and early twentieth centuries was based very heavily on the inspired work of practical men. While there were pockets of scientific research and expertise in the United States in certain fields and sectors, for the most part, the large manufacturing corporations that were at the center of America's growing wealth were based on practical inventions, on technologies borrowed from European companies, or on the results of "cut and try" improvements made over time on the factory floor.

Throughout this period, a small number of large corporations, such as AT&T, General Electric, DuPont, and General Motors, set up formal research and development departments, inspired by Thomas Edison's "invention factory" at Menlo Park, New Jersey, established in 1876. However, such laboratories were not common, and American universities produced very few graduates with advanced degrees in the natural sciences and even fewer in engineering.

As is widely known, America's experience in mobilizing scientific and technical resources to aid in waging World War II was a watershed in the commitment of federal funds and the construction of federal laboratories to support and conduct research on technologies for practical purposes. Government dollars to pay for R&D grew by roughly a factor of twenty from 1940 to 1951.[8] Giant federal laboratories were established, the R&D contract was invented, and government money flowed freely for the first time to support research in American colleges and universities.

As the war wound down, a panel of high level advisors to the president of the United States, chaired by Dr. Vannevar Bush, issued its famous report, "Science—the Endless Frontier," which advocated for sustaining federal support for research at universities and government laboratories after the war to help meet important needs of industry, the military, and public health. Central to the vision articulated in the Bush report was a key lesson drawn from the mobilization experience—generous public support of fundamental research in the sciences yields enormous benefits to the nation. On this idea, America built, not without controversy and struggle, several of the major government elements of its present national innovation system. Central to that system was the belief that "basic research is best."

What may be less widely recognized about Dr. Bush's report is that it also set the stage for a radical increase in corporate investment in scientific research and development intended to support innovation in technologies that could be successful in the commercial as well as the government marketplaces.

In the two decades following the end of World War II, U.S. industry established and funded a large number of new major corporate R&D facilities. Nearly every large corporation and many smaller ones built laboratories on the Bush model, often locating them far away from centers of manufacturing, operations, and sales. Many were designed to look like university campuses and were placed in suitably bucolic settings, staffed by as many advanced degree holders in natural sciences and engineering as could be enticed to leave academia.

It is also significant that reforms in engineering education that were widely adopted in the late 1950s and early 1960s emphasized the importance of deep understanding of scientific principles as the basis for technological progress. The engineering profession had found itself somewhat embarrassed by the challenge of conducting some of the more advanced research projects during the war and made the strategic direction to place fundamental science and mathematics at the heart of the engineering curriculum and research agenda.[9]

The importance of science to the American way of life was reinforced by the actions of the Soviet Union to test both atomic and hydrogen weapons in the mid-1950s and to launch the first man-made Earth orbiting satellite, Sputnik, in 1957. These events were widely interpreted as signals that America's scientific leadership was under threat, and they led to a redoubled commitment to fund scientific research and to encourage young people to make science a career. For talented young Americans who were contemplating college and career options in the late 1950s and early 1960s, science and engineering were the obvious choices.

Science became the model for many other aspects of American society. Systematic research in the social sciences paved the way for major social changes. For example, the winning side in the famous 1954 Supreme Court case that ended racial segregation in public schools, Brown vs. Board of Education, was buttressed by findings by social scientists about how children's learning was influenced by classroom segregation. Other social science findings provided the intellectual premises of public welfare programs and educational interventions such as Head Start. "Scientific medicine" became the watchword for clinical practice. Science even intruded into the realm of the spiritual as its evident powers of explanation contributed to a prominent national news-magazine asking, in the face of scientific advance and developments in modern theology, "Is God Dead?"[10]

Further evidence that America had become a "scientific society" was the development in the late 1950s of the professional field of "science policy." The post of Science Advisor to the President of the United States was created in the late Eisenhower administration, along with a President's Science Advisory Committee made up of experts who could be on tap to give the president and his top aides the benefit of the very best scientific understanding as they made decisions and advanced policies on everything from environmental problems to food stamps. By the mid-1960s, nearly every major government agency had a staff of scientists who were expert in its domain of responsibility. Furthermore, the growth of regulatory actions dependent on substantive scientific expertise was accompanied by a growing demand from the courts which expected, when regulatory actions were challenged, that a regulatory agency would support its decisions with a solid body of scientific evidence.

By the early 1960s, therefore, America had fully embraced its new relationship to scientific research and had truly become a "scientific society." With all due respect to the late David Halberstam, the "Best and the Brightest" young people were induced disproportionately into academic programs and subsequent careers in math, science, and engineering. Scholarships and fellowships were made available in abundance, and, once the military draft again became a reality for America's young men in 1965, the ready availability of draft deferments for science and engineering majors—often all the way to the Ph.D. and sometimes beyond with a "critical skills" deferment—reinforced this trend.

America's embrace of science—its findings, its methods, its theories—as the foundation for innovation, for culture, and for life has never been complete. Certainly, the relationship of science to society could be rocky at times, as evidenced by the emergence during the late 1960s of significant anti-technology strains in both the environmental movement and the anti-war mobilization against America's involvement in the Vietnam conflict. Despite these setbacks, however, it seems quite accurate to me to characterize America between about 1950 and 2000 as a "Scientific Society."

The National Innovation System for the Scientific Society

I now turn to observations on the nature of the National Innovation System that America constructed in the latter half of the twentieth century to mirror the larger societal organization around science; that is, to serve the Scientific Society. It should not be surprising that that happened, of course, since nothing is closer to the role of science in society than the use of that science by society to innovate.

As a general rule, National Innovation Systems result from a mix of conscious design and policymaking, combined with co-evolution of institutions, practices, beliefs, and happy accidents. Certainly, the United States did not collectively sit down to design its NIS.

The contemporary American NIS includes a number of important features. It is a very complex system that would require a book-length treatment for comprehensive illustration and analysis. Since many aspects of the current system are widely known, I will touch here on only a few highlights.

Since the conduct of fundamental research and its subsequent application are central to U.S. society, we can point first to the very heavy investment made by the nation in support of fundamental research. Basic research is the primary category of research done by faculty and graduate students in higher education. Funding basic research is the principal role of such federal agencies as the National Institutes of Health and National Science Foundation, and supporting basic research is also the responsibility of major parts of the Department of Energy, NASA, the Department of Defense, and the Department of Commerce. As part of its emulation of the Bush Report's model, industry has also supported and conducted substantial amounts of fundamental research.

Another important characteristic of the American NIS is its very heavy focus on research in the natural sciences and engineering within the fundamental research category. During the past half century, the specific fields of that research have evolved, from physics, chemistry, and electrical, chemical, and mechanical engineering after World War II, to the life sciences, computer science and applied mathematics, and systems engineering more recently.

The federal government is investing increasing amounts of money in supporting education in math, science, and engineering at all levels, from pre-K through post-doctorates. Achieving high competence in mathematics is one of the two focus areas of the No Child Left Behind Act. Belatedly, science will become a third focus area in the near future.

Tax policy related to innovation also has a bias toward the natural sciences and, indeed, to experimental natural science. For example, the federal research and experimentation tax credit (often referred to inaccurately as the R&D tax credit) is available only for experimental research and development and not for modeling and simulation or theoretical work. More important than the tax credit, however, is the tax provision that allows for either expensing or capitalizing expenditures on R&D by profit making entities.

Other federal policies and programs are part and parcel of the NIS, including the patent and copyright systems, various forms of subsidy for new and small firms such as the SBIR (Small Business Innovation Research), ATP (Advanced Technology Program), and STTR (Small Business Technology Transfer) programs, business consulting assistance for new technology-based firms, development of standards and methods of test by NIST (National Institute of Standards and Technology), federal technology transfer programs for universities and federal laboratories, and spin-off of inventions to the private sector from R&D activities in DOD (Department of Defense), NASA (National Aeronautics and Space Administration), and other agencies.

Many private institutions are important to the NIS as well. Sources of finance for innovation are important to firms of all sizes and all stages of development. As a general rule, debt financing is not available for innovation-related activities, which makes equity capital extremely important to successful innovation. The equity markets, venture capital, angel investors, and others are key parts of the NIS. It is widely believed that there is a tension between the equity markets' ever-sharper demands for short term financial performance and the need of firms for "patient capital" to carry out longer-term development projects. The recent trend toward private equity-based purchases of publicly-traded firms may help offset this trend, although that result is not guaranteed.

As indicated above, the American NIS is very complex. Conducting and exploiting fundamental research in the natural sciences and engineering are the most essential characteristics of this NIS. I have only touched on a few of the other most important aspects of the system to set the stage for later discussion of desirable attributes of the NIS for the Post-Scientific Society.

The Post-Scientific Society

America is, I submit, entering a radically new stage in its economic and cultural evolution; namely, it is becoming a "Post-Scientific Society." A Post-Scientific Society continues to make use of the latest in scientific discoveries, theories, and data as the foundation for innovation and change. However, in the Post-Scientific Society, producing new science gives way to using new science that is developed elsewhere. The new science that is used in a Post-Scientific Society often comes, not as raw data and information, but as knowledge embodied in devices, components, systems, and routines obtained from anywhere else in the world. In a Post-Scientific Society there is less demand for scientific talent, and fewer young people are drawn into the field by the promise of exciting opportunities and excellent salaries. Firms in a Post-Scientific Society retain smaller numbers of scientific professionals than in the past, and their role is more to serve as translators and exploiters of new science than as contributors to the body of scientific knowledge. Firms reduce their commitments to long-term, basic research and depend more on third-party providers of new knowledge.

In the Post-Scientific Society, as well, the creation of wealth and jobs based on innovation and new ideas tends to draw less on the natural sciences and engineering and more on the organizational and social sciences, on the arts, on new business processes, and on meeting consumer needs based on niche production of specialized products and services in which interesting design and appeal to individual tastes matter more than low cost or radical new technologies.

Businesses will not succeed in the Post-Scientific Society by adopting a fast-follower strategy, seeking to emulate the products brought to market first by firms in other countries. Rather, success will arise in part from the disciplined search for useful new knowledge, whatever its origins, that can be integrated with intimate knowledge of cultures and consumer preferences by using highly creative networks of creative individuals and collaborating firms to produce complex new systems that meet human needs in unexpectedly new and responsive ways.

The emergence of a Post-Scientific Society in the United States is, in a sense, simply the latest working out of the logic of comparative advantage among nations. The U.S. remains quite good at doing basic scientific research, as compared with other nations. However, when the costs of doing research in the United States are compared with the costs of doing it elsewhere in the world, the United States loses much of its advantage. Some of the comparative advantage of other countries in conducting science arises from currency misalignments and generous subsidies provided by their governments; but, even accounting for these market interventions, it is still less expensive to do science—world class science—in many other nations than in the United States.

As more and more nations have achieved a medium-to-high stage of political and economic development, they have been able to establish the necessary conditions in which scientific research can thrive. These include stable infrastructures for energy, telecommunications, and water and waste disposal services; a high quality educational system for at least some of its people; a commitment to challenging the status quo; a source of funds; and a reasonably stable political culture. Bright people are a natural resource everywhere, and, if the conditions listed above exist, science can thrive. Throughout the post-World War II period, the United States and other nations, as well as the major international development organizations, have worked to strengthen scientific infrastructures in many countries. It is now becoming apparent that those efforts, as well as the substantial efforts made by developing countries on their own, have been successful in many places.

In view of the increasing capability of the scientific communities in other nations, the United States has become a "high cost" place in which to do science. One need look no further than the recent rush by American companies to establish research laboratories in China and India for confirmation that the costs of research are lower there. While evidence can be adduced to suggest that lower costs are not the only driving force for locating R&D facilities in such places, nevertheless, the financial pressures to do so are clearly one factor in these locational decisions. To be sure, American firms have withdrawn substantially from the commitments they made in decades past to conduct fundamental research in their own corporate research centers. They have increasingly depended on universities, federal laboratories, research consortia, high-tech start-up firms, and overseas laboratories in the pursuit of low-cost sources of new knowledge and new technologies.

Other evidence exists to demonstrate that the United States has lost the unchallenged lead in science and research that it amassed in the decades after World War II. For example, in the fifteen years between 1988 and 2003, the U.S. share of published papers in the world's scientific literature declined from 38 percent to 30 percent,[11] and the number of publications by U.S. scientists remained essentially unchanged throughout this period. The shares of U.S. patents awarded to U.S. inventors in important fields like electronics and heavy machinery have declined in comparison with Japan and Germany, respectively.[12]

The declining interest in math, science, and engineering careers on the part of American young people has been a subject of wide-spread discussion for at least two decades. Recommendations for policies to stem this decline are a major focus of the Gathering Storm Report, for example. Remarkably, the public dialogue on this issue has proceeded on the basis of little original research and analysis, other than observations about the basic demographic data. Relatively limited attention has been paid to the workings of the ordinary law of supply and demand. Yet, it is not at all unreasonable to presume that prospective students in math, science, or engineering can observe that competition from overseas is rising even as salaries for degree-holders in some fields of science have stagnated or declined.[13] George Borjas has recently shown that a 10 percent immigration-induced increase in the supply of doctorates lowers wages of competing workers by 3 to 4 percent. A student contemplating a career in the sciences, which typically requires a doctorate, must surely be aware of the competition he or she will face in the job market from scientists from around the world, whether they have emigrated into the United States or whether they have been educated and do scientific research in other countries for less pay than their American counterparts. As competence in fundamental math and science has been enhanced around the world, these fields simply don't appear as attractive to American students as they once did. If, in fact, America is entering a post-scientific future, then "kids today" may be making wise career choices to focus their energies on something other than mastery of math and science.

There is a bright side to the Post-Scientific Society story. It is that we have clearly been turning our attention increasingly to matters more complex than the doing of fundamental science. We are moving up the scale of intellectual and societal complexity by specializing in activities that require the integration of all knowledge and capabilities to better serve the needs of individuals, families, companies, communities, and society as a whole. We still need to be able to understand and use the fruits of scientific research, wherever it is done, and we will continue to need a significant number of active scientists and other researchers working at the frontiers of knowledge. In key areas where we maintain a solid lead, as in fields of biomedical science, our incredible investments and deep intellectual infrastructure may suffice to enable us to dominate the research activities of other countries. Yet, even in biomedicine, it is increasingly clear that improving the quality of life for the majority of people involves not just applying sophisticated science-based medicine but also requires the integration of multiple disciplines concerned with human health, from nutrition, to exercise physiology, to gerontology, to social work.

There is an interesting parallel between what I see happening to our use of scientific research at the country level and what industry has been doing at the company level. For the past two decades, as noted earlier, American companies have been cutting back on their investments in long-range, fundamental research, and have turned instead to sophisticated product development based on integration of knowledge of markets, public policies, cultural trends, and—when needed—the results of fundamental research performed somewhere other than in the company. As a society, we seem to be moving in the same direction, only it is not yet as apparent.

As it has cut back on fundamental research, American industry has joined the call for more government support for basic research in universities. Industry has realized that the positive spill-over effects of basic research are difficult to capture and exploit, which is the fundamental economic rationale for public support of basic research. Moreover, more than two decades ago, I pointed out in congressional testimony that the economic argument for public support of basic research does not stop at the nation's border.[15] The new knowledge so generated becomes available all around the world at little or no cost, which means that it makes sense for countries to take full advantage of the research paid for by others. It also means, as discussed below, that there is a good reason to seek to organize many countries of the world in joint support of basic research, as is happening now in Europe for small science, and as has been happening for decades in "Big Science" projects like the space station and the particle accelerators at CERN (European Organization for Nuclear Research, originally Conseil Européen pour la Recherche Nucléaire).

Beyond the question of support for and conduct of science, however, the Post-Scientific Society involves something much more. Ours is becoming a society in which cutting edge success depends not on specialization, but on integration—on synthesis, design, creativity, and imagination.

Consider where the "action" is today in the "technology" sector of American industry—it's in information systems, multi-media production, "one-click" ordering, search engines, music and video downloading systems, multifunctional cellular and wireless telephony, and so on. To be sure, these "ride" on a deeply sophisticated infrastructure of broadband networks, high performance computers and servers, huge software systems, mass memory devices, and other technologies. These in turn "ride" on foundations of materials science, digital signal processing, computational algorithms, advanced measurement methods, and other fundamentals. The value added and the wealth generation is happening largely at the top level of this kind of hierarchy, not necessarily because the people and institutions at the top are so much more clever than any others, but because they face less competition from around the world.

Others are seeing some of the same phenomena. Richard Florida, for example, has focused on the human resources implications of what he calls the "creative economy."[16] His message is that the "creative economy" depends as much on lifestyle, diversity, tolerance, and local culture as it does on science-based innovation. The "creative class," on which so much economic development now depends, includes, according to Florida, not only people who work in science and engineering, but also architects, designers, educators, artists, musicians, entertainers, and creative professionals in business and finance, law, health care, and related fields. He says, "These people engage in complex problem solving that involves a great deal of independent judgment and requires high levels of education or human capital."[17]

Higher education is beginning to respond to the demands for new kinds of programs to meet the needs of students and employers interested in multidimensional, multidisciplinary educational experiences. For example, an increasing number of universities are offering degrees and concentrations in fields like "information technology," multi-media production, entrepreneurship, innovation studies, creativity, and other cross-disciplinary fields. Where just a couple of decades ago universities tended to treat interdisciplinary work as an intrusion into the "real" work of the institution's disciplinary departments, today the ability to inspire and lead such work has become a standard expectation of university leaders. Companies are stepping up the hiring of social and behavioral scientists, artists, designers, and poets. In recognition of some of these trends, the National Science Foundation has expanded its collection of data on R&D to include activities in the service sector.

It would be overreaching to argue that the United States has completed the transition to a "Post-Scientific Society." Instead, like all such transitions in the past, the characterization of such cultural eras is a statement about the leading edge of social and economic development. Just to highlight the point, while we ordinarily think of the Stone Age as the time before our pre-historic ancestors discovered metals, we continue to build in stone to this day and are proud of it. Likewise, if we have left behind the agricultural age, the machine age, and the age of steam, we still grow food, use machines, and depend on steam for our well-being. We will continue to need and nurture science, but it will, like the dominant cultural developments that preceded it, recede into the background as a necessary but no longer defining characteristic of our age.

The National Innovation System for the Post-Scientific Society

From the perspective of innovation policy, the core question raised by the emergence of the Post-Scientific Society is, what kind of national innovation system is required to support economic growth and wealth generation in this new world? Which elements of the current NIS continue to be needed, how should the current elements be modified to take account of the needs of the Post-Scientific Society, and what new elements must be invented and put in place to strengthen the foundations of this new form of economic activity?

The most important part of the NIS is always the part devoted to preparing the next generation of people who can participate successfully through innovation; wealth; and job creation. In the Post-Scientific Society the demands on innovators are very great—they must not only have a core understanding of scientific and technical principles, but also equally strong preparation in business principles, communications skills, multi-cultural understanding—including languages other than English, human psychology, and one or more of the creative arts. Their education must emphasize making connections—among ideas, people, organizations, and cultures, often across boundaries that no one has thought to try to cross before. Some contemporary observers point with great unease to the wired, connected way of life of contemporary American young people. I would argue that, even as computer games helped to prepare the current generation of computer-literate Americans, so will their hyper-networked world prepare the next.

It is important to reinforce that I am not arguing for a reduction in the role of science and technology in the education of the next generation; rather, I am arguing that we must find new ways to make scientific and technological literacy a part of the education of all students who wish to play significant roles in the Post-Scientific Society. At the same time, we must avoid making tragic errors in educational practices and policies that would leave our next generation less-well prepared if we focus too heavily on the skills our parents needed rather than on the skills our children will. For example, it is extremely distressing that K-12 school systems are finding it necessary to cut back on education in integrative subjects like geography and languages, as well as on the arts, in order to focus on developing “basic skills” in math and reading to meet the demands of the No Child Left Behind Act. It would be most unfortunate if some of our students were left behind in math and reading, but it would put the country’s future at risk to be left behind in the race to the Post-Scientific Society. We have to be certain that we emphasize what we want, for we shall surely get what we emphasize.

What about advanced education and research? Again, we need to maintain a cadre of scientific and engineering researchers who can work with confidence at the frontiers of human knowledge. They must, however, be able to do so in a networked world wherein collaboration across the world is as easy as collaboration down the hall, and is probably more productive for involving diverse perspectives on problems and their solution. In the next few years, it may be desirable to reinstate the foreign language requirement for the Ph.D. in science and engineering, not to put up additional barriers to success but to emphasize the multicultural basis of good practice. Further emphasis should be given to hybrid educational programs, like the “science masters” degree promoted by the Sloan Foundation, that add strong skills in business, public policy, culture, and creativity to the foundation of science laid down in the undergraduate years.

As discussed above, there will be increasing interest in a Post-Scientific Society in developing new international structures to support the conduct of basic research around the world. As we increasingly depend on basic research conducted elsewhere, Americans will want to have direct influence over which research is done and by whom, and we will increasingly seek to encourage other nations to cooperate with us in bearing the costs of that research.

The Post-Scientific Society needs an intellectual property protection system that is respectful of the fact that increasing portions of all industrial wealth lie in intangible property—in ideas, plans, designs, software, and human networks—and that protecting inventions manifest in hardware or materials will be less and less of the work of the Patent and Trademark Office. The Copyright Office has become increasingly important to a wider variety of industries as software and “media” content seek protection to sustain their value in a world of creativity. Somewhat paradoxically, the open-source software movement suggests that new modes of networked creation can flourish where traditional notions of ownership and control of intellectual property are turned on their heads.

The federal research agencies such as NSF, which should be at the forefront of the new directions in marrying science, engineering, culture, and economy, need to take a much more aggressive role in helping to shape these trends. Each step in broadening the base of the work of NSF to reflect new realities has come only after a long battle (one need only think of the extended campaigns that were needed a generation ago to put both engineering and the social sciences on a firm base in NSF). NSF should not only respond to "proposal pressure" but also stimulate new modes of research and thinking about how to thrive in a Post-Scientific Society. Simply redoubling our efforts to fund more research and to prepare more scientists and engineers along the models of the past is unlikely to be sufficient to meet the new needs. Contrary to the message of the Gathering Storm Report, it is not so much that we need more scientists and engineers but that we need new kinds of scientists and engineers.

Many other aspects of the National Innovation System will need to be modified to come into alignment with the realities of the Post-Scientific Society. For example, tax incentives for R&D, which are currently drawn quite narrowly by statute and regulation, need to be expanded to cover a wider range of activities than were contemplated when they were first adopted during the age of the Scientific Society if they are to function as effective encouragement to industrial innovation. Recognition awards should be given to those who excel in the marriage of creative, systems, and research activities, even as they are now given to those who excel in just one of these.[18]

A key issue of our time, and one that is related to my thesis about the Post-Scientific Society, has to do with the importance of place in the innovation of new ideas, technologies, works of art, politics, etc. On the one hand, in a world of networked individuals and institutions where everyone is accessible to everyone else in seconds, place hardly seems to matter. On the other hand, the agents of the new Post-Scientific Society, like the members of Florida's creative class, tend to congregate in places that have a number of desirable attributes. To some analysts, "clusters" of similar technology-based firms and industries seem to thrive. To be sure, encouraging the formation of clusters is a major tool of economic development officials today. Yet, if rapid economic change in response to a rapidly-changing, ever-networking world is the key to success, then clusters built around single industries may offer no greater assurance of long-term economic success today than the auto cluster offered Detroit or the steel cluster offered Pittsburgh a hundred years ago. Instead, places should seek to be attractive to a range of creative businesses, not just to clusters of firms in one industry or another.

Concluding Observations

My intention in writing this paper is to stimulate a robust discussion at AICGS and later in other venues of the new directions that a number of key institutions in the American innovation system need to take if they are to remain supportive of, and central to, the generation of wealth, growth, and opportunity for the next generation of Americans. I find the concept of an emerging Post-Scientific Society to be a compelling framework in which to think about profound changes now underway in America and in its relationship to the emerging industrial and scientific powers in Asia. It suggests new approaches to innovation and competitiveness policies that go well beyond the latest incarnation of time-worn proposals that amount to "just do more of the same." The Post-Scientific Society needs a great deal of further investigation and elaboration, including explicit consideration of the dark side that is only mentioned in a footnote to this paper.

NOTES

1 ©Christopher T. Hill 2007. Prepared for discussion at a meeting on 4 June 2007, in New York, NY, of the project on "Advancing Innovation, Enhancing the Economy: A German-American Project," sponsored by the American Institute for Contemporary German Studies, Washington, DC. Support by the Institute is gratefully acknowledged. I have benefited from discussions of the issues in this paper with numerous colleagues, especially with George Heaton, Kent Hughes, Bill James, Robert Morgan, Shuzaburo Takeda, and Patrick Windham.

2 The concept of the Post-Scientific Society was first developed by the author at a meeting of the Business-University Forum of Japan in Tokyo on 15 September 2004. See www.buf-jp.org/topicse.htm.

3 Other characteristics of the Post-Scientific Society are less attractive. In brief, they include a decline in general public understanding of the methods and findings of science with an associated growth in the popularity of a very wide range of transcendent modes of apprehending the world, a general decline in the respect given to specialized scientific and technical knowledge in the making of public policy, and a decline in the popular ability to discriminate between scientific and pseudo-scientific claims. These are not the focus of this paper, but deserve serious consideration in the near future.

4 National Research Council, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, 2006." http://newton.nap.edu/catalog/11463.html.

5 Richard R. Nelson, ed., *National Innovation Systems: A Comparative Analysis* (Oxford: Oxford University Press, 1993).

6 Richard R. Nelson and Nathan Rosenberg, "Technical Innovation and National Systems," in Nelson, op. cit., 4.

7 It is important to note at the outset that "scientific society" as I use the phrase does not mean the application of scientific principles to "manage" society. My formulation has nothing in common with the obsolete conceits of scientific socialism.

8 In "Science—the Endless Frontier," Vannevar Bush reported federal expenditures on research of $69 million in 1940. The first systematic annual survey of federal R&D funds by the National Science Foundation reported federal "obligations" for R&D of $1.52 billion in 1951, or some twenty-two times more than Bush reported for 1940. See www.nsf.gov/statistics/nsf01334/pdf/hista.pdf. These two estimates are not strictly comparable, as they were obtained using different definitions of both "R&D" and federal budget categories, but the factor of more than twenty swamps any technical adjustments that might be made to try to put these data on the same basis.

9 "Report of the Committee on Evaluation of Engineering Education," Journal of Engineering Education (September 1955): 25-60. Reprinted in the same journal, January 1994: 74-94 and made available on the web by the publisher at: www.asee.org/resources/upload/The-Grinter-Report-PDF.pdf. This report became known as the "Grinter Report" after the chairman of the committee, L.E. Grinter.

10 *Time*, 8 April 1966. The magazine's cover is at www.time.com/time/covers/0,16641,19660408,00.html. The following excerpt from the cover story suggests the spirit of the times, "Anglican Theologian David Jenkins points out that the prestige of science is so great that its standards have seeped into other areas of life; in effect, knowledge has become that which can be known by scientific study—and what cannot be known that way somehow seems uninteresting, unreal. In previous ages, the man of ideas, the priest or the philosopher was regarded as the font of wisdom. Now, says Jenkins, the sage is more likely to be an authority 'trained in scientific methods of observing phenomena, who bases what he says on a corpus of knowledge built up by observation and experiment and constantly verified by further processes of practice and observation.'" www.time.com/time/magazine/article/0,9171,835309-6,00.html.

11 U.S. National Science Foundation, "Science and Engineering Indicators—2006: Chapter 5."

12 Ibid.: Chapter 6.

13 For example, starting salaries of chemists at all degree levels peaked in constant dollar terms around 1999 or 2000 and have declined since, although with a slight move upward for those who received their degrees in 2005. See Michael Heylin, "Class of 2005 Salaries and Jobs," *Chemical and Engineering News*, (7 August 2006): 57-64.

14 George J. Borjas, "Immigration in High-Skill Labor Markets: The Impact of Foreign Students on the Earnings of Doctorates," National Bureau of Economic Research, Working Paper No. 12085 (March 2006).

15 Christopher T. Hill and Joan D. Winston, "The Nobel-Prize Awards in Science as a Measure of National Strength in Science," Testimony before the Science Policy Task Force, Committee on Science and Technology, U.S. House of Representatives, 16 April 1986.

16 Richard Florida, *The Rise of the Creative Class* (Basic Books, 2002).

17 Ibid: 8. (page reference to the paperback edition, 2004)

18 It is instructive that the Academy Awards for achievement in the technical aspects of film making are usually given before the prime-time television program at which awards are given for acting, directing, producing, and other creative aspects of cinema. Shifting the technical awards to a more visible place on the program would better recognize those who are defining the leading edge of their business/art.

02 SOURCES OF INNOVATION IN GERMANY

SOURCES OF INNOVATION IN GERMANY: HOW NETWORK EFFECTS DRIVE INNOVATIVE INDUSTRIES

JAN U. BECKER

The precursory AICGS Policy Reports on innovation in the United States and Germany provided a detailed picture of the different facets of innovation, both on a micro and macroeconomic level. This paper aims to combine both levels on the basis of two exemplary innovative industries by analyzing different sources of innovation and deriving implications for German policymakers.

Introduction

By definition, innovation describes the act of introducing new ideas, methods, services, or devices to markets and is typically seen as a major driver of the economic wealth and growth of nations. Innovations are believed to create seminal economic value for the benefit of companies and the overall economy by inducing technological and structural changes, which result in the creation of jobs and property for the innovation's owners. These benefits emphasize the need for policymakers to create a climate in which innovation prospers. In order to do so, it is necessary to understand what forces drive innovative markets and how public and private investments in innovative enterprises interact. This is especially valid in times of limited resources. Policymakers have to decide which innovative industry should be supported and venture capitalists must carefully weigh which enterprise they should invest in. This paper uses two examples to explain cases in which policymakers can exploit the existence of network externalities[1] to stimulate market growth and leverage the effect of public investments in innovative industries.

Rather than joining in the chorus of extant literature on success factors of innovations,[2] this paper draws on structural sources of innovation, the evaluation of their influencing conditions, and the derivation of industry-specific implications for innovation policy. From an academic point of view, von Hippel's fundamental work provides many insights on sources of innovation that directly relate to network effects.[3] First, he recognized the importance of know-how trading between innovative firms and its consequent welfare effect. Using the example of the German biotechnology industry, this article portrays the effects of current innovation policy and illustrates measures to further stimulate industry growth. Second, reverting to von Hippel's "lead users," that is, those users that function as examples for others, as main sources for innovations, this paper shows how network externalities revolutionize the media industry and how traditional practices in innovation policy are being challenged by the emerging e-entertainment industry.

Who Innovates Today?

Though seemingly facile, the question of who actually innovates today depends on the point of view. Taking a rather process-oriented stance, one would refer to the expenditures on research & development (R&D) as key indicators as to whether or not companies or industries are innovative.[4] Basing the judgment on the tangible results of innovative processes, we can observe the number of patents as a subsequent indicator for innovativeness and come to the conclusion that the innovation climate in Germany is perfectly fine. According to the most recent statistics available from the European Patent Office, German innovators accounted for 18.4 percent (about 25,000) of all patent applications in Europe in 2006, securing second place in international comparison. Only U.S. inventors had more patent applications (about 34,600) registered during that time.[5]

Researching the source of innovation though, we need to ask who filed the patent applications and in which industrial sectors. Not surprisingly, over 90 percent of all patent applications derive from industrial innovators, i.e., companies.[6] Considering that the German Patent and Trade Mark Office (*Deutsches Patent- und Markenamt*) saw about 12,000 German applicants filing for patents in 2006, it strikes as noteworthy that only 3.8 percent of those applicants accounted for almost 60 percent of all patent applications! Clearly, the primary sources of innovation in Germany are large companies (e.g., Siemens, Bosch, or DaimlerChrysler). Similarly obvious are the reasons: large enterprises possess adequate financial resources and necessary knowledge bases within their own companies in order to realize economies of scale in R&D.

Also notable is that the majority of innovations in Germany are still occurring in the automobile, mechanical, and electrical engineering industries. Bearing the concept of the Kondratieff cycles[7] in mind (Figure 1), it would be expected that those industries already identified by the media and policymakers to be crucial to Germany's future success (i.e., Kondratieff cycle 5 and 6) are at eye level with more traditionally innovative industries. However, innovations related to the information technology and biotechnology sectors each account for only 5 percent of all patent applications.

In order to evaluate the current situation of innovative sources in Germany, let us reflect on the specific positions of the two innovative industries mentioned above—biotechnology and information technology, specifically, e-entertainment. Interestingly, both industries show rather contrary outcomes in regard to the sources of innovation, the effect of network externalities, and the role of policymakers.

A Perspective View on Biotechnology in Germany

Judging by its growth rate in the past few years, the German biotechnology industry tells quite a success story. With total revenues of €1.54 billion in 2005 and about 13,000 highly-qualified jobs, Germany's 480 biotech companies have already reached considerable economic significance. As for their innovative potential, the companies have invested €714 million in research & development.[8] This is especially remarkable because the shift towards modifying biotechnology regulations was only initiated in the mid-1990s by policymakers.

Although these figures are encouraging, German biotech enterprises still lag behind their British and American counterparts with regard to personnel, funding, and marketable products.[9] Ultimately, it is not the absolute numbers but rather the implications for the position of German biotech companies on the global market that indicate suboptimal macroeconomic returns on the long run.

THE SITUATION OF BIOTECHNOLOGY IN GERMANY…

The background of this rather pessimistic assessment is an insufficient critical mass of biotech companies in Germany today, which constrains network effects and results in a situation of inadequate knowledge transfer and causes a lack of incentives for biotechnological research. Although politicians have acknowledged the necessity of fostering the settlement and establishment of biotech companies, existing efforts made so far, such as the BioRegio competition that encourages regional initiatives for biotech clusters, have failed to stimulate an adequate number of biotech foundations to settle and expand in Germany.

The underlying reasons are diverse. In a knowledge-based industry like biotechnology, interaction and interchange—i.e., knowledge transfer—between regionally proximal companies and research institutions foster a climate of both cooperation and competition, resulting in economic growth. Von Hippel discusses the advantages of informal know-how trading between companies in competitive and cooperative environments, and Keilbach describes the welfare impact of localized interaction on the knowledge creation in an industry. Starting on the basis of an innovation, an entrepreneur launches a company in order to produce and market the innovative product. As production increases, employees develop products and innovation-specific skills and form a specialized labor force. Attracted by the success of the company, other enterprises attempt to benefit from the established pool of specialized labor and open a location nearby. In this case, knowledge from one company spills over to other companies, inducing further research, further specialization of employees, and an even further growth within the cluster of innovative enterprises.[10]

Nevertheless, adequate knowledge transfer as a result of network effects requires the interaction of a critical mass of players. Hence, research institutions and universities are recognized to be vitally important as seedbeds for innovative research. However, knowledge transfer in innovative industries is not just a matter of political will, but also a result of entrepreneurial activity and the subsequent interaction of existing skills and competitive advantages within a region. Unfortunately, it is not as easy as picking one university, attracting investors, lecturing on entrepreneurship, and subsequently an innovative industry cluster emerges.[11] Although German universities are excellent in fundamental research, they often lack the focus on application and patent-oriented research: in 2006, the total number of patent applications filed by universities was only 645 (compared to the total of over 48,000 applications in Germany).[12]

Even if policymakers assist in concentrating scientific and economic potentials by defining long-term goals and providing beneficial legal conditions, their efforts can only prepare the ground for individual entrepreneurial activities, as public funding is designed to have a catalytic function and serves only as a jump start for further private investments.[13] This plan works well in theory and, admittedly, in particular cases, e.g., the BioRegions Heidelberg and Munich where adequate connections to research institutions and public seed funding mobilize private investments to endorse emerging companies that start research in biotechnology. Unfortunately, a multiplicity of reasons often undermines the desired effect and causes rather limited efforts in biotech R&D.

First, from an investor's point of view, research on biotechnology is not only highly time-consuming but also associated with an uncertain outcome—developing a drug may take between ten to fifteen years in which thousands of compounds are narrowed down to one marketable product.[14] Therefore, financing new enterprises that base their existence on extremely time-consuming innovation processes with imponderable outcomes constitutes an indefinable risk for founders, investors, and employees. Evidently, venture capital for biotech startups is rather scarce in Germany. In 2005, a total of €222 million in venture capital was invested.[15] Interestingly, more than 65 percent of those funds were given for third (or later) round financing indicating the cautious activities of investors in Germany. Not only is public funding below international levels; private investment per financing round, on average, mobilizes significantly less venture capital for German biotech companies than equivalent enterprises in the U.S.

Second, if tax laws also fail to address the specific situation of a strategically and economically important industry, even fewer incentives are provided for potential investors. In particular, current German tax legislation does not account for risk and, therefore, fails to support stakeholders.[16] Since financing high-risk ventures, i.e., biotech startups, is not treated, fiscally, any different than less risky investments, investors and potential entrepreneurs have the opportunity to easily realize higher returns elsewhere. Furthermore, by applying regular income tax on employee gratifications (e.g., stock options), existing tax laws not only discourage employees to work for newly founded companies, they also dilute a viable instrument for those enterprises to preserve scarce assets and to motivate their employees at the same time.

…AND ITS CONSEQUENCES

As for the biopharmaceutical sector, the consequences are conspicuous. Of those companies with ongoing research, we find 63 emerging enterprises, in comparison to 20 established companies. The operating figures are obvious: whereas emerging companies realize, on average, revenues of €7 million with a staff of 45 employees, established companies rely on much higher resources with revenues of €134 million and almost 800 employees. Confronted with these figures, the fact that established enterprises account for the majority of the overall revenues in the biotechnology industry seems less remarkable.[17] Whereas countries like Japan, Canada, or Norway encourage smaller companies' R&D activities by granting tax privileges, German tax law does not differentiate between small- and medium-sized companies and big enterprises.

Evidently, we are witnessing a dilemma in which Keilbach's circular causation for innovation clusters is seriously disturbed (see Figure 2)[18] Due to the lack of incentives for investing labor and money in the creation of new firms, the biotechnology industry has not been able to establish a self-sustaining process of innovation. This has caused a malfunction of knowledge transfer between the enterprises and public research institutions continuing to date.

The example of biotechnology in Germany shows that success in knowledge-based industries is highly dependent on the availability of financial resources. As for innovative industries, science and capital are equally important; the German innovation policy has yet to provide for adequate incentives to foster R&D in the biotechnology industry. Under these circumstances, we can suspect that the spread between emerging and established companies in regard to their macroeconomic impact will further increase unless policymakers intervene.

The Situation of E-Entertainment in Germany

The second example is the e-entertainment industry, which actually combines the two innovative industries of information technology and entertainment. The entertainment industry is innovative by definition. Both content and media are in constant change, competing for the consumer's attention.

Because entertainment contents are considered hedonic goods (i.e., goods that provide an experiential consumption, fun, and pleasure),[19] they correspond with a decreasing marginal utility for repeated consumption—only a few people feel the same excitement after watching the same movie or reading the same book again as they did the first time. Consequently, the entertainment industry is constantly innovating to provide its consumers with new texts, pictures, videos, and music (e.g., the annual new releases of the book industry in Figure 3)[20].

Notwithstanding the innovative power of the entertainment industry, German legislation considers some types of media content as "merit goods" and promotes them accordingly. In the case of the media industry, we witness the support for culturally important goods such as books, radio, and TV programs in Germany. Thus, books are subject to special, reduced sales taxes and resale price maintenance, implemented by legislation. Culturally favorable radio and TV programs in Germany are promoted through the Öffentlich-rechtlicher Rundfunk, a network of radio and TV stations that benefits from obligatory fees paid by all Germans who own a radio or TV set. The general rationale of "merit goods" is well-meant: in order to ensure the supply of certain commodities that a) face a too small demand and b) are, nevertheless, considered to be essential and of cultural value to society, public policy overrules consumer sovereignty and subsidizes its production. In the following, this paper examines how e-entertainment is changing the media industry and what consequences this development implies for today's media policy.

RECENT MEDIA DEVELOPMENTS…

Whereas the type of medium used to determine which type of content was communicated, in terms of e-entertainment it is the content that determines its medium. Due to the digitalization of content and the development of information and communication technology, the consumption of entertainment content and, subsequently, the interaction between content providers and consumers, has evolved into the era of e-entertainment. Throughout the world, the technological infrastructure regarding high-speed internet access and powerful multimedia technologies is growing rapidly. In Germany, the online community will reach over 60 percent of the population above the age of 14 in 2007.

In the case of biotechnology in Germany, we saw that situational conditions influence industry performance (unfortunately for the worse) and determine its structural composition. Conversely, the entertainment industry is facing a powerful trend that is shifting market powers towards a demand-driven industry with quite contrary structural effects, fueling numerous startups (e.g., MySpace, Facebook, YouTube, or flickr) as sources of innovation. Those companies are reacting to consumer needs by offering excellent services almost always free of charge, and have already reached enormous audiences within a short period of time. Examined more closely, it becomes obvious that today's emerging media companies share common traits and benefit from a number of shortcomings of the incumbents.

First, the business model of large traditional media corporations is usually based on rigid and established value chains where all activities are controlled. This happens either by vertical integration or strong linkages to suppliers or distributors. Due to economical interactions, the incumbents abstain from providing products and services that might endanger the structures by cannibalizing existing offers. An example from the movie industry portrays this dilemma: to date, no adequate service for Internet users exists to legally access premium movie content. By deliberately ignoring consumer preferences, the movie industry tries to sustain cinema and movie rental revenues. And whereas the established companies are either not willing or able to wage the risk, the emerging enterprises easily fill that gap (e.g., Joost, KaZaa). The incumbent's denial of central customer needs only yields a demand surplus which can easily be addressed by clever startups. Their services become highly popular with their users—not only because they are offered for free. Additionally, young e-entertainment companies strengthen their popularity by creating emotional brands that live on their image of opposing established companies. These brands (e.g., Napster) are becoming icons in their fight against the "sluggishness" or the "profit orientation" of the media industry, with users taking pride in being members of that community.

Second, by serving customer needs, offering services free of charge, and providing its users a warm feeling of belonging to a trendy community, the e-entertainment startups are able to reach a critical mass of users swiftly. After reaching this critical mass, network effects induce a self-accelerating growth process that leads to even faster market diffusion.

Finally, successful emerging media companies hold the central position in the e-entertainment value chain and focus on the intermediary function between media supply and demand. As an intermediary, the startup is able to shift costs for content generation (e.g., MySpace or YouTube) or content distribution (e.g., through decentralized networks like Napster or Skype) to its users. This low cost base enables the startups to provide a free service and, thus, attract users. Furthermore, involving its users in the value creation (e.g., blogging, rating a book, or editing one's own Facebook page) also intensifies the brand image and the utility derived from the community membership.

The integration of users into the value chain is not trivial, however. For this to work, the user needs to understand all forms of utilities that are connected with the community. Due to network externalities, both the individual's own and the cumulated utility will increase with the number of active users and/or content provided. Therefore, the user needs to feel as a part of the community (e.g., the FON moviménto) which he reckons to be worth supporting. Additionally, the user understands that the community is not only about internalizing the utility of consumption but also actively providing and, thus, helping others. By contributing to the community, users can also express themselves, becoming stars within the community (e.g., lonelygirl15 on YouTube).

…AND THEIR ECONOMIC CONSEQUENCES

Interestingly, and quite contrary to the example of biotechnology, we find that in demand-driven sectors, such as the entertainment industry, where fast market response is vital, company size affects a product's or firm's success rather negatively and favors emerging companies. From an overall economic point of view, this development could be understood as the result of innovation and technological change and assumed that it even provides for an increased generation of economic value as described above. Pessimistic voices claim that emerging e-entertainment content and services are not only challenging the value chain of the traditional media industry, they are also threatening their business models.

Due to the limited time budget of individuals for media consumption, the different content and media offers are rival and, therefore, compete for consumer attention. Evidently, traditional media consumption (e.g., TV, newspapers, or radio) has steadily decreased over the years, whereas time spent online has increased. This development favors e-entertainment services not only directly in regard to popularity, but also indirectly as advertisers follow the shift in consumer attention and Internet ad spending grows accordingly.[21] The consequences for established media corporations could be devastating. They are witnessing their core business and advertising revenues deteriorate, while more people turn to e-entertainment content. Although consumers benefit from the diversity of content and media, the results on the macro-economic level could be negative. The Web 2.0 development has not only seen the democratization of the media industry; with millions of amateur writers and editors contributing only for the feeling of "warm glow" or the fame within a community, the incremental value of entertainment content is diminishing. Decreasing returns for the established media industry and jobs lost within the economy will be the consequence.

Strategic Implications

As both examples from biotechnology and e-entertainment show, the success of knowledge-based innovations are crucially determined by network externalities. However, the role of policymakers in the process of innovation differs significantly.

REVIVING THE INNOVATION CLIMATE FOR BIOTECHNOLOGY

As other examples in knowledge-based industries show (e.g., Silicon Valley or the Boston or Cambridge areas in Massachusetts) network effects exist within clusters of companies of one industry and build upon the regional availability of both knowledge and capital. In spite of commendable initiatives that have been undertaken in the past, for the special case of the biotechnology industry in Germany we must assert that situational conditions have prevented network externalities from becoming effective. The reasoning for this is obvious: inefficient public and private funding, compounded with restrictive tax legislation, have discouraged the founding and settlement of an adequate number of biotech enterprises. Without a critical mass of research institutions and companies within a regional cluster the knowledge transfer between the regional players is insufficient. Consequently, neither companies hoping to participate in or profit from knowledge transfer nor investors are willing to transfer their assets in those regions.

Although the figures show that the described conditions do not affect the larger, established biotech companies, we can expect serious negative implications for emerging enterprises. Instead of a constant economic growth and the creation of new jobs, the lack of network externalities in the German biotech industry results in long-term competitive disadvantages.

How can German policymakers react to this situation? Although innovation is predominantly an entrepreneurial topic, policymakers are responsible for paving the way for the possibility of successful investments by entrepreneurs and venture capitalists in R&D in biotechnology. This can be achieved by increasing financial support for research institutions in order to keep domestic highly-skilled researchers and attract foreign ones. In return, German research universities need to focus on research topics that are market relevant and lead to a higher number of patents from universities which, consequently, lead to higher revenues. By initiating incubators for startup companies, universities should simultaneously encourage students and faculty to act as entrepreneurs and assist with necessary funding and knowledge. The close ties that can be developed between the research institution and the emerging private companies would provide a steady transfer of knowledge back and forth.

This rather practical help that incubators can render needs further assistance, especially when venture capitalists are hesitant to invest in German biotech companies. Policymakers need to consider appropriate investment incentives to encourage these venture capitalists. Increasing public R&D spending to an internationally comparable level and competitive allocation of funds would not only result in providing necessary incentives for entrepreneurs, it would also trigger additional private investments. If venture capitalists do decide to invest in R&D intensive and economically favorable industries, tax laws should account for the risk an investor accepts and encourage such investments. This is especially relevant in the founding stages of emerging enterprises. Furthermore, a reform of the corporate tax legislation in Germany (e.g., R&D tax credits) would not only stimulate R&D, but also encourage the founding of startup companies in knowledge-based industries. Overall, only by creating a positive climate for initial investments can policymakers motivate both entrepreneurs and investors to engage in high-risk ventures, including biotechnology.

REASSESSING THE CORE COMPETENCIES IN E-ENTERTAINMENT

As portrayed above, the business models in the e-entertainment industry are also successfully based on network externalities. Therefore, content creation and consumption in terms of e-entertainment is predominately cost-free. Nevertheless, entertainment startups are able to provide excellent services, custom-fit for their users' needs, usually based on a community spirit that unites the users. Since the services are mostly free of charge it is understandable that users indulge in those offers and spend their limited budget (i.e., time) on these new services.

By integrating their customers into the creation, aggregation, marketing, and distribution of content, e-entertainment startups such as YouTube activate network externalities. The active participation of users in the value creation strengthens their identification with the community and increases their engagement with the startup brand. Also, outsourcing important parts of the value creation and remaining only with the intermediary position leads to an efficient cost structure and relative independence of high venture capital investments. Additionally, negligible marginal costs and network externalities yield a high marginal utility for the individual and the community. The consequences for the traditional entertainment industry are grave. The startups compete not only in the user's media consumption, but also in each step of the value chain and, unlike in the biotech industry, small emerging e-entertainment companies hold advantages over the established players.

As we ask for the value proposition of new forms of media dispersion, we need to evaluate the sustainability of current trends. Figure 4 shows the predicted development of content quantity and quality as Web 2.0 services mature. The figure also shows the anticipated path of competition from user-generated content aggregators to traditional media corporations. At the beginning, all user-generated content aggregators face the problem of not having reached the critical mass of content. However, due to network externalities and "winner takes all" effects, we observe that at least a few aggregators begin to generate a sufficient amount of content to become interesting enough for a large scale of users. Whereas the quality of the content is perceived by traditional media corporations as inferior, the user's perception is different.

User enjoyment of amateur content provided by thousands of other users leads to more traffic to the respective website (e.g., YouTube or GoogleVideo). Interestingly, some sites have started providing a revenue share model to content providers. For example, GoogleVideo offers a revenue share model to content providers who have proven copyright ownership of the (video-) content. This increases the incentive for semi-professional content distributors to offer their content online. With the increasing availability of content, the problem of editing it arises. This function is partially executed by Google or YouTube, but also completed by users which rate the content. This form of semi-professional editing helps users to find better content, which subsequently draws more users and yet more content to the site. In order to establish the service as a high-quality-content service, Google or YouTube have already implemented semi-professional sourcing strategies by providing incentives or services to large scale content providers such as independent movie producers. The next step will be professional editing (programming) and professional sourcing for top content, which will then lead to a premium content provider capable of competing with traditional media corporations.

Figure 4 shows the dilemma of media corporations. The process can be observed in photo publishing (Corbis versus Flickr), in the music business (peer-to-peer networks that have broken the traditional power held by record labels leading to new opportunities for players like Apple to enter the market), and in the video business (e.g., YouTube, Google). Due to user-generated content and the respective network externalities, content aggregators are growing into business fields that have traditionally been defended by media corporations by installing strong market entry barriers. However, new technologies (such as Ajax) change user's preferences and provide opportunities for start-ups to overcome these market entry barriers.

As previously ascertained, political interventions for the sake of merit goods should primarily serve an adequate supply of goods that are socially desirable (e.g., because of their cultural value) and would have otherwise not been produced. In times when e-entertainment services profit from an enormous pool of diverse international suppliers of textual, audio, and video media content allowing them to serve the "long tail," the latter argument fails.[22]

Even the first argument should not hold as justification for the existing protective measures in favor of merit goods. Although we witness enormous growth rates for the emerging enterprises and decreasing returns for the incumbents, large and established media corporations still have the possibility to participate in the boom of the e-entertainment industry; for example, by using their financial power to take over competitors and "buy in" the market power they wish to possess. The same effect is reached with the strategic partnerships that Clement and Jahn point out.[23]

Ultimately, the business models of established media corporations are affected in both cases. The relevant questions to be asked for these established market powers are not how to continue making money or asserting their fleeting market power, but rather, in what new direction media usage is going to develop and how they can become active players and avoid marketing myopia. Rather than modifying their own business models, the more fitting questions to ask are what medium future customers are going to use and how to re-imagine their businesses accordingly. Instead of aiming to maintain their present business model, margins, and control over markets, they should strive for alternative ways of generating revenue from new forms of content dispersion, even without advertising.

Conclusion

The two exemplary industries presented in this paper have given some insight into quite contrary sources of innovation. Common to both industries are the supporting consequences of network effects for the value creation and their importance for success. What differ are the implications for policymakers. For industries that rely heavily on special know-how, network effects caused by local knowledge transfer—either between research institutions and companies or between companies—lead to a self-sustaining process of innovation. In this case, policymakers should provide stimuli for the local foundation and settlement of enterprises in favored industries, such as biotechnology, in order to reach a critical mass of companies. Since public financing and tax laws in Germany haven fallen short to provide this climate so far, we miss positive network externalities so far.

Whereas network effects on the supply side most likely require adequate measures from policymakers, demand side network effects will most likely reach a sustainable and socially preferable equilibrium even without political intervention. In the case of the media and entertainment industry, we witness such equilibrium already. Young enterprises that built powerful communities and motivated their users to produce, bundle, market, and distribute content took advantage of network effects, captured parts of the traditional media value chain, and provided for an enormous supply of media content. In the era of e-entertainment, policymakers should, therefore, revise measures established to ensure the provision of deemed merit goods.

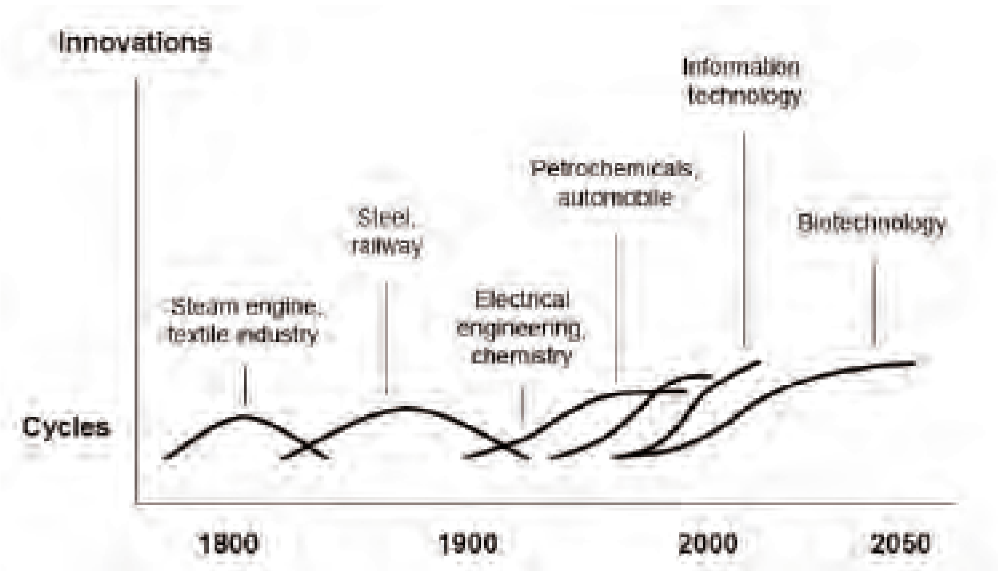

Figure 1: Kondratieff Cycles

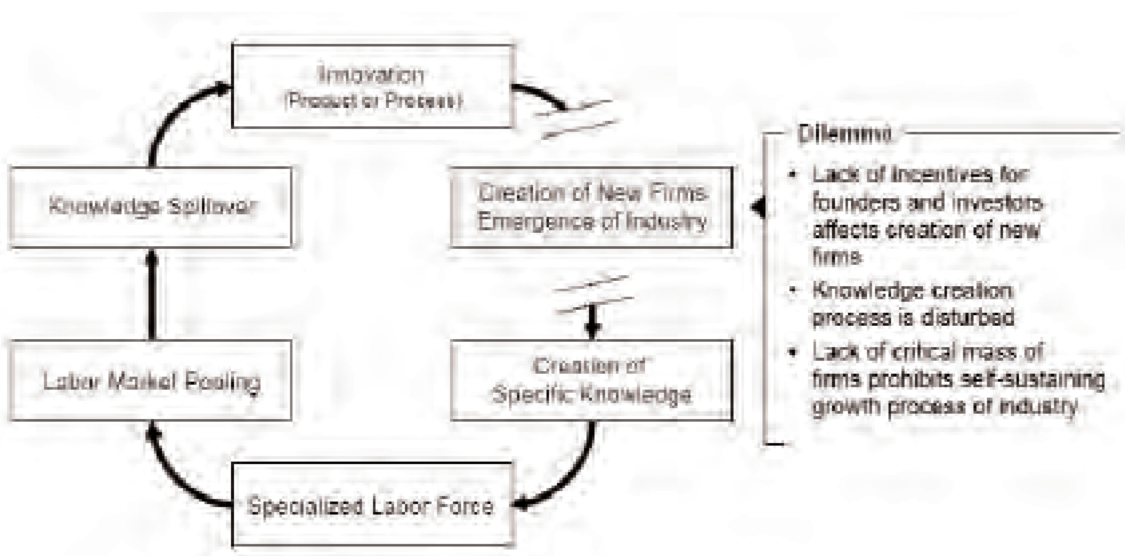

Figure 2: Dilemma of Biotech Startups in Germany

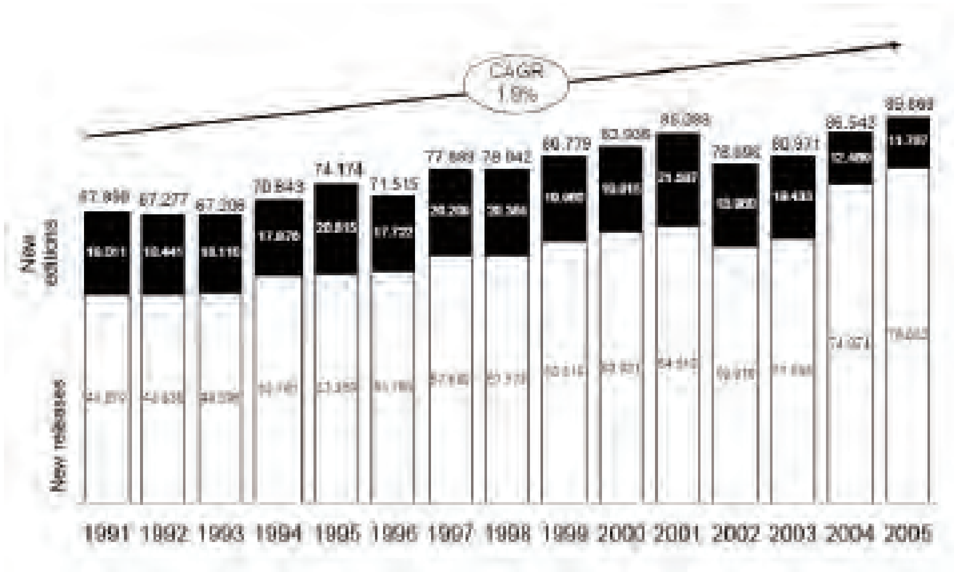

Figure 3: Book releases in Germany

* CAGR: Cumulative Annual Growth Rate

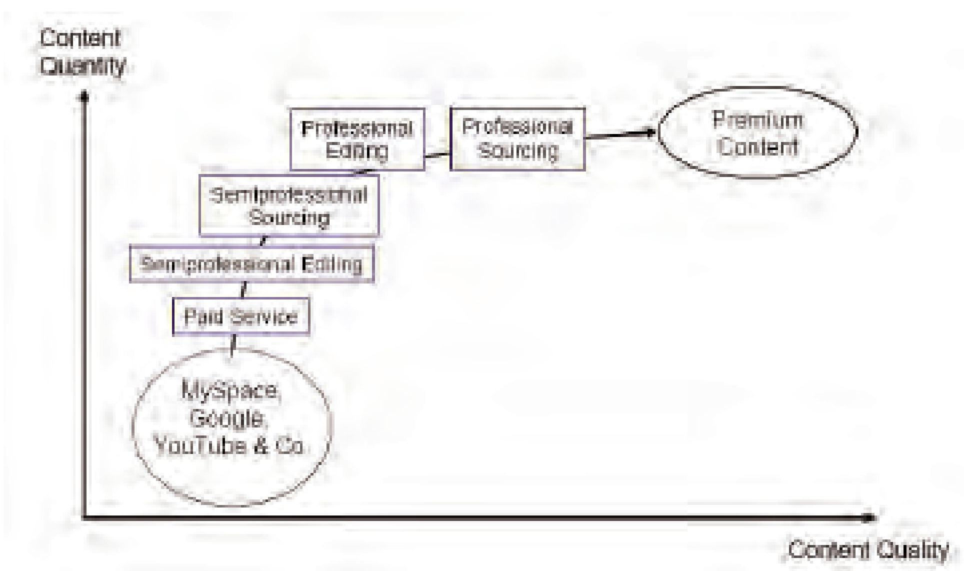

Figure 4: Strategic Development of Web 2.0 Platforms

NOTES

1 In this context, network externalities depict an above-average increase in value to an entity in the case that further entities join the existing group of entities. Entities can both be companies clustering in one region and Internet users contributing to an online community.

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10 Max Keilbach, *Clustering of Innovative Industries in Germany: The Example of Jena*, AICGS Policy Report No. 27 (Washington, DC: the American Institute for Contemporary German Studies, 2007): 9-21.

11 Carolin Häussler and Hans-Martin Zademach, "Cluster Performance Reconsidered: Structure, Linkages and Paths in the German Biotechnology Industry, 1996-2003,“ *Schmalenbach Business Review* 59 (2007): 261-281.

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17 Emerging (< €30m) and established companies (> €30m) were distinguished on the basis of revenue. Boston Consulting Group, *Medizinische Biotechnologie in Deutschland 2006* (Munich: Boston Consulting Group, 2006).

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AICGS

1755 Massachusetts Ave., NW
Suite 700
Washington, D.C. 20036 – USA
T: (+1-202) 332-9312
F: (+1-202) 265-9531
E: info@aicgs.org
www.aicgs.org

AMERICAN INSTITUTE
FOR CONTEMPORARY
GERMAN STUDIES

THE JOHNS HOPKINS UNIVERSITY